LOUISIANA TECHNOLOGY INNOVATIONS FUND FINAL REPORT
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I. DEPARTMENT / AGENCY

Louisiana State University, Department of Physics and Astronomy

II. PROJECT TITLE

"Training Today's Students for Tomorrow's Internet Work Environment"

III. PROJECT LEADER

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IV. DESCRIPTION OF THE PROJECT

During this project we will develop a system to provide today's school children with experience in using the internet to control, access and operate robotic instruments much in the way that they may in tomorrow's high technology network based work environment. This will include internet control interfaces for the Highland Road Park Observatory telescope, for the ATIC balloon-borne "space" experiment and for a HAM radio satellite communication system. In addition a group of teacher leaders will work with us to develop a curriculum that will provide the context and structure necessary for students to use these internet accessed instruments effectively. During the project we will partner with various community and business organizations such as HAM radio operators, amateur astronomers, Southern University, LaSPACE, and a local television station to provide needed expertise and to enhance the quality of the product. The final products of this project will include a set of operational internet "robots", the materials necessary to train teachers in the use of these devices, the supporting classroom materials to be used by students, and an evaluation of the project effectiveness based upon classroom assessments

V. POST IMPLEMENTATION REVIEW AND ASSESSMENT

A. Executive Summary of Findings

This project, using the working title of “Robots for Internet Experiences (ROBIE)”, was initiated May 15, 2000 and successfully completed on June 30, 2002. During this two year time span we 1) developed and deployed three internet accessible “robots” at the Highland Road Park Observatory (HRPO) for use by teachers and classrooms; 2) established a series of web sites to control the ROBIE instruments and disseminate educational information; 3) Developed the capability at the HRPO to train teachers in content knowledge and the correct use of the ROBIE instruments; 4) were assisted by a Teacher Leader group who developed the educational materials necessary to guide teachers and students in the use of the "robots"; 5) conducted a pilot workshop to train a small group of teachers in the use of the educational materials and instruments; 6) followed these teachers and their classrooms over the course of the year to assess the effect of the current ROBIE concept; and 7) laid a foundation for expanding ROBIE beyond the initial three instruments. The project successfully showed that technology in the classroom available over the internet can be a highly cost effective mechanism for educating and inspiring students about science and technology. It also became clear during the project that technology in the classroom cannot be an end in of itself. Rather, that technology must be accompanied by development of lessons and materials that guide the use of the technology, assuring that these materials are aligned with existing curriculum and content standards, and teacher training in science / technology content as well as the use of the technology lessons and guide materials. The pilot workshop and classroom evaluations conducted during the last program year showed us ROBIE strengths and areas where improvement would be useful. With this information we will continue to refine ROBIE using available resources.

B. Accomplishments and Best Practices Identified

One of the primary goals of the ROBIE project was to develop the hardware / software necessary to bring three modern instruments into the classroom over the internet including the Highland Road Park Observatory (HRPO) optical telescope, a HAM radio station and a cosmic ray balloon experiment.

The first interface to be brought online was for the Advanced Thin Ionization Calorimeter (ATIC) cosmic ray balloon-borne experiment. This ~4000 pound NASA sponsored experiment was built almost entirely at LSU and is carried to the very edge of space (~120,000 feet) for a ~15 day trip around the continent of Antarctica by a helium filled balloon large enough (~30 million cubic feet) to almost fill LSU's Tiger Stadium. The ATIC interface (http://atic.phys.lsu.edu/aticweb/) provides teachers and students with descriptions about the experiment science, pictures of the instrument construction, testing and flight preparation, as well as real time tracking of the experiment and near real time access to the ATIC housekeeping data during flight. In collaboration with WAFB TV the interface also includes a series of videos, produced by Bill Rodman, that follows the ATIC team of scientists and technicians as they travel to Antarctica during the fall of 2000 and prepare the experiment for launch. These videos, including an hour long documentary on ATIC subsequently produced by Bill Rodman, were used by teachers to dramatically illustrate the real world of scientists and science. In addition, the housekeeping data (e.g. temperatures, pressures, status) provided students with a concrete example of how to analyze actual scientific instrument data. ATIC is scheduled for a reflight during fall, 2002 and once again students will be able to follow the progress of the experiment in real time.

The second "robot" develop was a satellite tracking HAM radio station. The hardware here includes the tranceivers, power supplies, packet decode / encode and antennas necessary for radio communication across the HAM frequency bands. In addition, the antenna mount is motorized on two axis to enable the antenna to be remotely pointed in any direction. The full setup is computerized and a web interface to the radio and antenna control has been developed (http://www.bro.lsu.edu/radio/). Using this interface teachers and students can track and listen to the signals from satellites, the space shuttle and the International Space Station as they pass over southern Louisiana. Several of the lessons associated with this instrument illustrate and emphasize the role that satellites play in our daily lives. In addition, those teachers or students become licensed HAM operators can also use the interface interface for the radio to transmit voice and contact other HAM operators around the world. One future project we are planning is to schedule classrooms to talk with astronauts on the space station as it passes over Baton Rouge.

The third ROBIE instrument to be placed online is the optical astronomical telescope at the Highland Road Park Observatory (HRPO). This interface gave us the most trouble and we tried several approaches finally settling on a combination of commercial and custom software. The software is based upon the Astronomy Common Object Module (ASCOM), which is a grassroots standard for automation and interoperability among astronomy analysis and instrument control software. The commercial software purchase for the HRPO includes MaxIm DL/CCD to control the CCD camera and process images, PinPoint to determine the exact pointing direction of the telescope, Starry Night Pro to provide an online interactive star chart and Astronomers Control Panel (ACP) to provide interactive telescope control, an automation interface and a built-in web interface. To this commercial software we also had to develop a custom ASCOM compliant driver for the HRPO observatory system plus a multi-tasking interface program. This software has worked well and enabled remote operators on the internet to control the HRPO telescope and take images. However, the commercial software is designed with the amateur astronomer in mind who is generally very familiar with telescope hardware / software and is usually located close to their observatory. Thus, there were several constraints placed upon how teachers could access the HRPO and these issues will be discussed further below.

In conjunction with the hardware / software effort we also organized a group of Teacher Leaders to assist in the development of lessons and materials that would guide the use of the ROBIE instruments. Such material is necessary if we expect teachers to use the ROBIE technology in the classroom. Further, the materials, as much as possible, need to structured so they are straight forward for the teachers to use. Therefore, during the material development the Teacher Leaders took into account 1) the Louisiana science content benchmarks that provide a standard for teaching science across the K-12 grades; 2) exemplary materials such as "Universe at your Fingertips" in order to not redo effort; and 3) existing Louisiana middle and high school curriculum to help teachers integrate the ROBIE project into their school program. A total of 26 lessons were developed and each ROBIE instrument has a particular guiding theme. For the ATIC instrument the theme is "Real science and data analysis". Lessons were constructed to illustrate how the scientific method is actually used by scientists, how real scientific investigations are actually conducted, and how data returned by experiments is analyzed. The theme for the Radio instrument focuses on artificial satellites and the role of this technology in our society. Several lessons include showing how satellites affect our daily lives, predicting satellite passes over Baton Rouge, observing satellite both by eye and with the radio. Other lessons also illustrate the difference between sound and radio waves as well as giving the students experience with the first telemetry encoding scheme: Morse Code. The Telescope instrument obviously has an astronomical theme with lessons on How Telescope Work, Sunspots, the moons of Earth and Jupiter and Messier Objects. To disseminate this material a central ROBIE web site was established (http://www.bro.lsu.edu/) from which teachers and students could gain access to the lessons and guide material as well as to the internet control interfaces for the various instruments.

Even with the instruments and lesson material available over the internet, teachers would still have difficulty integrating the units into their classroom without some formal hand-on training. We therefore enhanced the capability at the HRPO to train teachers in content knowledge as well as the correct use of the ROBIE instruments. These enhancements included a cluster of PC workstations so that teachers could practice how to use the ROBIE software, a computer projection system for group instructions, plus various supplementary materials necessary to teaching the content.

An important component in the ROBIE project is to evaluate how well the lessons and internet instrument work in the classroom. Therefore, during summer, 2001 the Teacher Leader group organized and held a pilot workshop to train a group of teachers in the use of the ROBIE instrument, classroom lessons and materials. This workshop was held July 30 through August 1 and included 9 teachers who had previously participated in the LSU Department of Physics & Astronomy PLATO program. Prior to attending the workshop all teachers plus their school administration agreed to test the ROBIE material in their classrooms. We then followed the efforts of these teachers throughout the academic year as they presented the classroom material and used the internet instruments with their students. To fit this special project into existing curriculum we had to distribute the three project units over the academic year. During fall, 2001 the teachers worked with the ATIC balloon experiment, during winter, 2001-2002 they used the HAM radio system and during spring, 2002 they focused on the telescope instrument. At the end of each unit evaluation material from each teacher participant was collected and analyzed. The evaluations we received have allowed us to judge the effect of ROBIE in the classroom and to update the classroom material as necessary. Summary evaluations for each ROBIE unit are provided in Appendix A. Support for this teacher training and classroom evaluation part of the ROBIE project is provided by Louisiana State University, NASA and other funds separate from LTIF.

By the end of Summer, 2001 I found that I was anticipating a significant cost savings in the project due to decreased computer and networking hardware costs, unneeded Professional / Contract services and reduced software package costs. As a result I requested from LTIF and was granted the ability to rebudget this cost saving into equipment that would enhance the ROBIE project. These enhancement items include a low cost, commercial technology remote control telescope system in collaboration with Louisiana School for Math, Science and the Arts (LSMSA), a radio telescope as a fourth ROBIE instrument, improvements in the HAM radio capability, enhancements in the teacher workstation cluster capability and portable, computer controlled telescopes for teacher / classroom instruction. In addition, I have purchased sensitive video cameras for projecting real-time images from the telescopes on-site or over the internet. All these components have been received and are in the process of being installed or configured. Finally, the auxiliary telescope has been delivered to LIGO and we are in the process of completing the design for the telescope housing. Work on integrating all remaining components into the ROBIE program is continuing and will be supported by available resources.

C. Benefits Achieved / Expected

A major benefit achieved by ROBIE is the sharing of a single set of technical equipment across many classrooms in the state by use of the internet. This allows teachers and students access to modern scientific equipment they would not normally be able to afford. As described in section B the three ROBIE instruments (ATIC, Radio, Telescope) were located in a central site, linked to the internet and provided with lessons to guide the classroom activities. While the pilot classroom evaluation involved only a small group of teachers, this effort showed that more than 400 students from grades 7 to 12 in 10 classrooms scattered around the parishes of East Baton Rouge, Ascension and West Feliciana were able to make use of the ROBIE "robots" and lessons (See Appendix A). Thus, ROBIE has proven to be a very cost effective mechanism for bringing high technology into the classroom.

A further benefit was achieved in providing students with new understanding of the technological world around us. In particular, several teachers described their students as having their eyes opened when they finally realized how much satellites affect their daily lives, or in awe as they predicted and observed a satellite passing over Baton Rouge, or were challenged to draw conclusions from real instrument data, or inspired by the pictures of galaxies and nebula they obtained from the telescope. While using hands-on, inquiry-based activities in the classroom to drive the learning process has been known for some time as a very effective method for teaching science, ROBIE brings such activities to the next step by providing teachers and students with instruments that can illustrate and probe modern science concepts.

D. Pitfalls Encountered

One of the primary difficulties we encountered during the project was with the internet access software for the telescope as described in Section B. While we were able to work around many of these difficulties by using a combination of commercial and custom software, this software does not include all the features necessary to allow the HRPO telescope to operate in full "robotic" mode. The commercial software was developed for the amateur astronomer market where it is generally assumed that the telescope operator is in close proximity to the backyard observatory. Thus, safety features like weather sensing and power outage shutdown control could not be implemented. In addition, we discovered that due to the relatively narrow field of view of the HRPO telescope the automated position sensing and control features built into the software was not 100% reliable. Thus, it is currently necessary for teachers to operate the telescope remotely only when a person is on-site at the observatory and this limits classroom access to the system. We are currently working to overcome these problems. In addition, the telescope system purchased for the LSMSA site takes advantage of many technology enhancements that have taken place since the HRPO observatory was built. These advances include an automated telescope housing and control system that has built in rain sensing and power outage safety feature. We have also purchased a similar system for the auxiliary telescope to be installed at LIGO. We are also working with the vendor of the automated position sensing software to improve the reliability of this software for smaller field of view systems. This effort to continue to move toward full "robotic" control of the telescope system is a continuing effort using available resources.

A further problem is that there are still many schools in Louisiana that are not connected to the internet, many classrooms that do not have adequate computer resources and many teachers who do not have sufficient training in the use of computers and the internet. Several of the teachers in the ROBIE pilot classroom evaluation reported problems related to these kinds of infrastructure issues. Several of the ROBIE lessons were designed with these kind of issues in mind and, consequently, could be done in a classroom with minimal or no computer / internet resources. These kinds of classrooms, however, cannot take advantage of the ROBIE instrument and miss the full impact of the lessons. It is our understanding that the state continues to place high priority in bringing these essential tools of the 21st century, i.e. computers and the internet, into every Louisiana classroom.

E. Recommendations to Agencies Planning to use this Technology

ROBIE has proven to be particularly effective in bringing modern scientific instrumentation into the classroom over the internet. Using this technology, a single set of instruments can be simultaneously shared by multiple classrooms across the state. After the initial investment associated with establishing the central pool, recurring costs are minimal and include only equipment maintenance and teacher training workshops. By avoiding risky shipment of the equipment from school to school, wear and tear on the equipment is minimized and maintenance costs are reduced. Teacher training workshops should be scheduled yearly and include science content as well as specific training in the ROBIE instruments and lessons. As seen in Section C, more then 40 students per academic year are impacted for each teacher trained in the use of the ROBIE instruments and lessons. In fact, the training a teacher receives during one workshop can be used for multiple academic years so the number of students impacted for each teacher trained may be a factor of 3 to 5 higher. Yearly workshops would increase the number of instrument users and the number of students impacted each year. Only when the current set of instruments become saturated with users would another set of equipment need to be purchased. From current data it is difficult to estimate when such saturation might happen as no scheduling problems occurred during the pilot evaluation. A very conservative estimate might be 100 to 200 teachers per equipment site, but this number could be much higher.

Appendix A
Summary of the ROBIE Classroom Evaluations
By Erin Babin, Celeste Carmouche, Greg Sollie

ATIC Summary Report

Advanced Thin Ionization Calorimeter, ATIC, was brought to area middle and high schools through a series of activities taught in class to relate classroom science to real life science in our world today.

ATIC was utilized in over ten classrooms during the 2001-2002 school year. The grades covered seventh through twelfth. Teachers were asked to complete at least three of the main activities. Scientific Method, and ATIC Quest introduced the project to 455 students and Data Analysis enlightened 398 students to interpreting large amounts of data into useable information. Teachers who completed the three required lessons averaged four to five class periods and a few teachers were able to devote more time and completed four to five lessons in eight to eleven days.

Overall the ATIC project has enlightened all the students' understanding of how concepts learned in the classroom are actually used by scientists on a daily basis.

Teacher Activity Evaluation:

ATIC Quest

Two high school teachers found the questions too broad and difficult for the students. Suggestions were to add career focus and retype worksheet (need numbers and rewording). Main concern is the students having access to the answers on the web. When they type in the search box it will bring you to a chart with the answer key listed on it, once they click here they have all the answers. Overall the teachers liked the lesson. The use ranged from using it as a classroom lesson to completing it after finishing other work to assigning it for homework to be turned in later.

Combining ATIC Quest and Mapping Antarctica gives the students an excellent introduction to the project. Teachers' use of the video clips from the Internet allows the students to meet the ATIC team and experience the scientific process with them

Scientific Method

Main concern again is the students having access to the answers on the web. Although some teachers thought the lesson too high or difficult to "pull" information out of the story, the majority of the teachers found it very useful in applying the Scientific Method and showed how the traditional Scientific Method is not always followed in steps. By using the activity students relate the scientific process skills taught in class to actual scientific experiments being conducted. We found this helps the students to transfer the process to other experiments through out the year.

Data Analysis

Again the problem with the students having access to the answers on the website for the worksheet. It is hard for them to "discover" this when they can find it on the web so easy. Suggestion to take out some of the directions in Excel was made, because they are not needed. If students do not know Excel the lesson will take another 2-3 days to complete. The majority of the teachers did not have access to the software. Overall the teachers though this lesson to be challenging to the students. In using the Data Analysis activity students observe massive amounts of data gathered in the ATIC experiment and begin to analyze useable data. The activity enhances students understanding of seasons and sun angle through evaluating causes of altitude change.

Mapping Antarctica

Suggestion to find a better polar map, need one with a smaller scale. Add more information on the site about circumpolar and vortex winds.

ATIC Component Statistics:

Teachers spent 4 to 11 days teaching ATIC.

Most teachers who completed only 3 lessons took 4 to 5 days.
Other teachers who completed 4 to 5 lessons took 8 to 11 days.

Number of students participating in ATIC lessons:

Scientific Method 455
ATIC Quest 455
Data Analysis 398
Mapping Antarctica 315
Circumnavigation 30

Grades participating in ATIC

1 - 7th Science class completed 3 lessons taking 4 days
3 - 8th Science class completed 4 lessons taking 8 days
1 - 9th Math class completed 3 lessons taking 4 days
1 - 10th Math Geometry class completed 4 lessons taking 5 days
1 - Physics class completed 3 lessons; classes were 1.5-hour blocks, no time frame sent.
1 - 10, 11, 12 class completed 5 lessons in 10 to 12 days and a Geography lesson.

Radio Summary Report

Radio Component Statistics:

10 teachers including 5 middle school teachers and 5 high school teachers taught the Radio Unit. The unit was taught to a total of437 students in East Baton Rouge and outlying parishes including Ascension and West Feliciana Parish. The unit was taught in 10 different schools, 7 of which are public schools and 3 of which are private. Of the 437 students that participated, 308 of these were middle school students and 129 were high school students. The breakdown by grade level is as follows: 36 -7th graders, 272 - 8th graders, 50- freshmen, 31-sophomores, 36- juniors, 42- seniors. On average teachers taught 4 lessons and spent about 7 days on radio in their classroom.

The feedback from teachers showed that most lessons were successful in their classrooms.

Teacher Activity Evaluation:

The Importance of Satellites

This lesson was an "eye opener" for many students. Teachers thought this lesson was a great introduction to what satellites do and students got a good appreciation for all that we have as opposed to 50 years ago. The middle school teachers were most enthusiastic about this unit and spent more time on it than high school teachers.

Radio versus Sound

This lesson was also well received by both teachers and students. Teachers thought the lab had predictable results and really helped to reinforce student knowledge of electromagnetic waves. This lesson was a "huge hit" and helped to clear up student misconceptions about radio and sound waves.

Viewing and Tracking Satellites

During this lesson teachers encountered the most difficulties. The technology that was required to conduct the lesson was the center of the difficulties. Teachers reported such problems as not being able to install net meeting, not having access to the computer lab, difficult to follow directions and confusion with why students were able to hear the satellite. Those classes that were successful with this lesson reported that students were in awe as they viewed the International Space Station and Iridium flares.

Morse Code

This lesson was reported to be the one most enjoyed by students. It was an exciting lesson that captured student's attention and lent itself well to cross-curricular activities. The one difficulty reported with this lesson was that the materials were expensive and hard to find So teachers used a variety of materials to conduct the investigation.

In addition to these lessons teachers also reported having done an extensive study of wave mechanics before beginning the unit and two teachers enhanced the lessons by having their students polish mirrors for the Starshine Satellite Project .

Recommended Enhancements:

Importance of Satellites -In this lesson we will include an introduction designed to draw out student misconceptions about satellites. To begin the lesson each student will be handed an index card. On one side of the card they will draw a picture of what they think a satellite looks like and on the other side they will list 3 uses of satellites. A chart will be included which students can use to identify differences between the Jenna's Day stories.

Viewing and Tracking Satellites -Specific instructions will be given as to where to locate the satellite information on the Heaven's above website.

Morse Code - One new worksheet will be provided to students that will incorporate Internet research.

Radio v Sound - No needed changes

Other -Two new algebra lessons created by a participant will be included in the packet .

Telescope Summary Report

Telescope Component Statistics:

5 teachers including 3 middle school teachers and 2 high school teachers taught the Telescope Unit either entirely or in part. The unit was taught to a total of 296 students in East Baton Rouge, West Baton Rouge, West Feliciana and Ascension Parishes. The unit was taught in 5 different schools 4 of which are public and 1 private. Of the 296 students that participated, 222 were middle school and 76 were high school. The breakdown by grade level is as follows: 95 students were in the 7th grade; 135 students were in the 8^{th} grade; 31 students were in the 10^{th} grade and 35 students were in the 12^{th} grade. On average, teachers taught 4 lessons and spent about 9 days in their classroom.

Teacher Activity Evaluation:

Sunspot Tracking

The first required lesson was the Sunspot Tracking Lesson and was the hit of all hits. Each teacher raved about the knowledge students gained as a result of this lesson. Basically students had zero (0) concepts about sunspots and by the end of the lesson, they were very excited and knowledgeable about them. One teacher need extra things to do so she made a new activity .The SOHO site was of great use and help according to the teachers. One teacher actually touched on sunspots all during the school year , which made for even deeper learning.

How Telescopes Work

The How Telescopes Work lesson was a mixed bag, from a "very easy one day lesson" to "hard for them to understand the comparison". Overall, the lesson needs more review. The diagrams need better reproduction. One teacher reported the interest of the students investigating telescopes on the internet. The lesson was quite useful during instruction of mirrors and lenses at the high school level.

Messier Objects

The third required lesson, Messier Objects was viewed as a great lesson overall. Teachers thought that the pictures taken with the Highland Road Park Observatory inspired students and enhanced the lesson. Some problems arose such as lack of internet, and lack of proper time, etc. Starry Night Pro was a great help to both students and teachers. Student presentations were very informative.

Sunny Faces of the Moon

One of the optional lessons was Sunny Faces of the Moon. Overall reaction was the rate of failure of placing the moon phases in correct order. The lesson was perceived as good and will be used again in future. Starry Night Pro was used here to show the phase changes of the moon.

Asteroid Introduction

The Asteroid Introduction Lesson was done by two teachers. Both had good reactions to the lesson, especially because of the Baton Rouge Asteroid. Interest among students was high because of the recent movies on the same subject.

HR Diagram

One teacher completed the HR Diagram Lesson. The teacher commented on the fact the lesson needed to be completed before the Messier Object Lesson.